



US ARMY NATICK SOLDIER CENTER:

The Science Behind the Warrior: Yesterday, Today and Tomorrow

In-Theatre Microclimate Cooling

Walter Teal
(508) 233-6096

walter.teal@natick.army.mil

Bruce Cadarette
(508) 233-4429

Bruce.Cadarette@us.army.mil

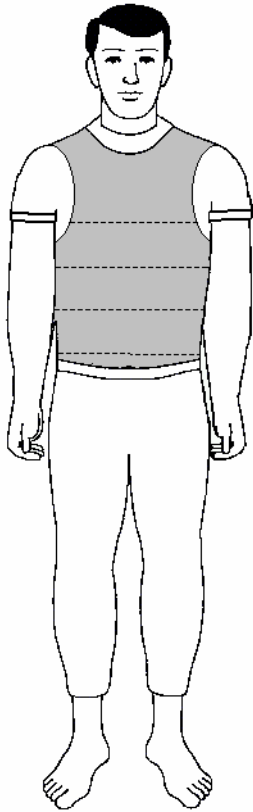
Brad Laprise
(508) 233-5440

brad.laprise@natick.army.mil

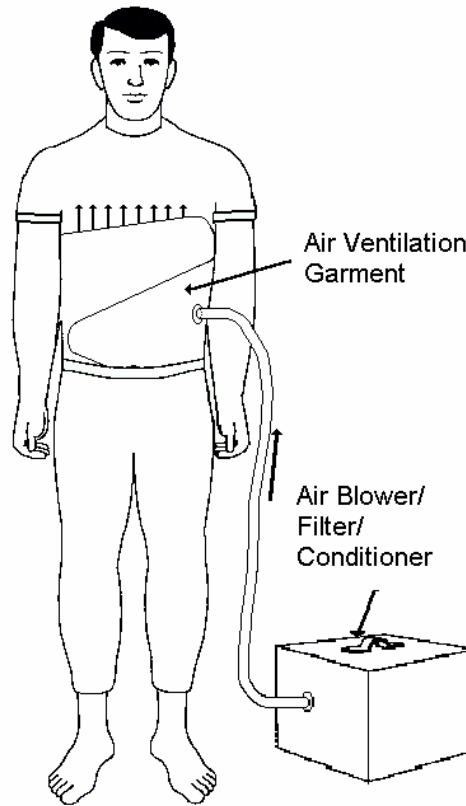




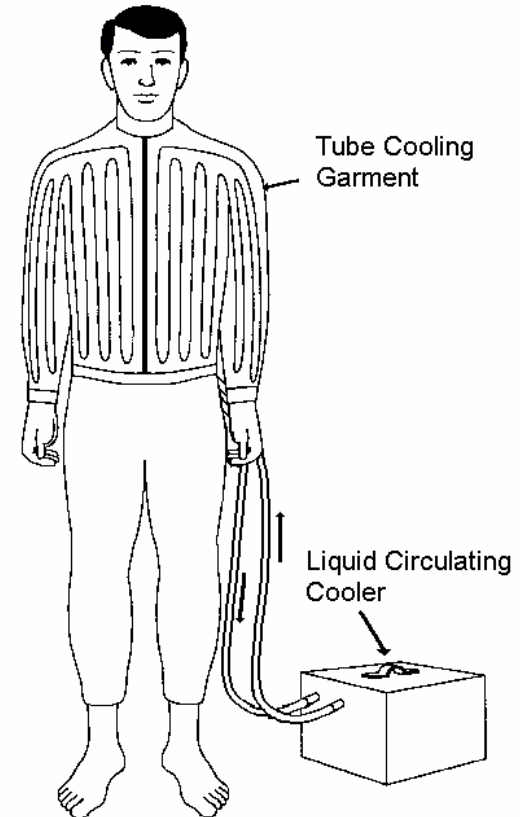
Microclimate Cooling Concepts



Passive System



Air System



Liquid System



Microclimate Cooling Requirements

Guidelines

- There is not one cooling system that will satisfy the needs of all users all of the time
- Need to understand the technical, operational, logistical implications/trade-offs of a system/technology



Microclimate Cooling Requirements (cont.)

Parameters to identify/define/consider:

- Weight (fixed/variable)
- Duration/Mission Length (time between replacement of consumables)
- Size
- Logistics (re-supply of batteries, cooling packs, filters, etc.)
- Integration/compatibility with Clothing and Individual Equipment (CIE)
- Tethered vs. non-tethered (mobility vs. carried weight trade-off)
- Support equipment available (battery chargers, freezers, etc.)
- Noise
- Cooling Garment configuration (shirt, vest, trousers, cap, etc.)



Overview of Cooling Systems

Heat Mitigation Strategy	Cooling Level	Cooling Duration	System weight (carried by Soldier)	Support Required
Ventilation vest with wicking tee shirt	Minimal (environment dependent)	Infinite	A few ounces	None
Blower add-on to ventilation vest	Low (environment dependent)	4 hours	< 5 pounds	Battery replacement every 4 hours
Med-Eng Body Cooling System	High	45 minutes	8 pounds	Ice bottle change every hour; replace battery every 2.5 hours
Personal Ice Cooling System (PICS)	High	30-60 minutes	11 pounds	Ice change every 30-60 minutes; replace battery every 4 hours
Air Warrior Microclimate Cooling System	High	Infinite	2 pounds	Vehicle power: requires AW microclimate cooling unit mounted on vehicle



Overview of Cooling Systems (cont.)

Heat Mitigation Strategy	Cooling Level	Cooling Duration	System weight (carried by Soldier)	Support Required
Steele Vest (ice pack cooling)	Moderate	1.5 to 2 hours	11 pounds	Ice packs
Armored Vehicle Microclimate Cooling System	Moderate	Infinite	2 pounds	Vehicle power/air conditioning system: requires Flow Control Assembly

Cooling Levels

Minimal (comfort) = < 50 Watts

Low = 50-100 Watts

Moderate = 100-175 Watts

High = 175-250 Watts



Body Ventilation System (BVS)

- Provides *ambient air* active ventilation capability to Soldiers in warm environments
- Sweat evaporation between DCU/ACU and IBA; integrated with MOLLE
- CRADA with Global Secure Safety (GSS)
- “Cooling” capability dependent on ambient conditions (best between 85 & 100°F in dry air)
- BVS consists of
 - Ventilation Unit (VU)/Battery – 3.3 lbs
 - 8 hours duration on lithium ion battery
 - Air Distribution Garment (ADG) – 1.0 lb
- ~ \$800





Commercial Off the Shelf Med-Eng PC230D

- Liquid circulating/ice based system
- Tube garment
- 2 liter ice bottle
- ~1 hour cooling between bottle changes
- ~2.5 hours operation on battery charge
- 8 pounds
- Logistics
 - Requires spare 2 liter bottles and freezer(s) to recharge them
 - Spare batteries/rechargers
- ~\$1500 ea
- Manufacturer (Med-Eng Systems) willing to work with customers to make modifications to system



Used in ISR at BAMC



Personal Ice Cooling System (PICS)

A battery powered mini pump circulates chilled water between the NBC sealed ice bag and a tube garment to remove metabolic heat from the body.

- 30-60 minute ice change-out
- Four hour battery change-out
- Three alkaline D-cell batteries
- Weight: 11 pounds
- Slightly bulkier and heavier than Med-Eng PC230D system





Air Warrior Microclimate Cooling System

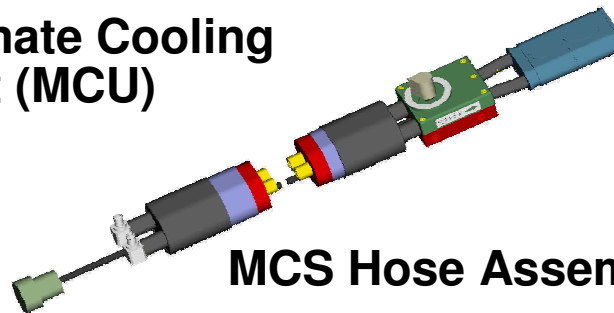
- Chilled liquid circulated to garment to cool aircrew
- Autonomous cooler takes heat from the fluid rejects heat to warm (ambient) air
- Current Applications: UH-60A/L, M9 ACE, CH-47D, OH-58D
- As of Jan 07, 843 aircraft received the MCS kits
- Unlimited cooling duration as long as power is available
- High level of cooling
- Could be used in hospital setting in tethered mode



**Microclimate Cooling
Garment (MCG)**



**Microclimate Cooling
Unit (MCU)**



MCS Hose Assembly



Commercial Off the Shelf Steele Vest - Phase Change

Passive Phase Change Material (PCM) Cooling
Products: Materials that change phase from a solid to
liquid to provide cooling

- Ice or paraffins are most common
- No moving parts
- Multiple configurations (vest, hat, neck wrap)
- Requires freezer/refrigerator to recharge PCM
- Requires cooler to transport PCM
- Outer clothing may have to be opened/removed to replace PCM
- Cooling rate decreases over time
- Cooling rate/duration dependent on type and amount of PCM
- Bulky
- ~\$9-\$350





Commercial Off the Shelf Microclimate Cooling Systems

Compressed Air Products: Air distribution garment connected to a compressed air source

- User is tethered; system is not autonomous
- Pass-through device may be required in outer clothing to accommodate hose
- Compressed air source required
- Cooling rate constant over time
- Some products use vortex tubes to refrigerate air
- Cool air may blow on patients
- ~\$100-\$260





Microclimate Cooling

General Observations/Conclusion

- Many commercial Microclimate Cooling products available
- Evaporative systems provide minimal cooling under protective clothing
- Ice based Passive systems provide more cooling than paraffin systems on a per weight basis
- Active liquid systems provide consistent cooling, but require tether or large logistical support
- All have technical, logistical, cost, and operational trade-offs
- Cannot identify the “best” product without understanding specific user needs/requirements



Microclimate Cooling POCs

Please contact us if you have any questions on microclimate cooling systems:

U.S. Army Research Institute of Environmental Medicine (USARIEM):

Bruce Cadarette

(508) 233-4429

Bruce.Cadarette@us.army.mil

U.S. Army Natick Research Development and Engineering Center

Brad Laprise

(508) 233-5440

brad.laprise@natick.army.mil

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